Space Weather Technical Forecast

Issued on Sunday, 18 December 2022 at 00:59 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-class flares Likely. Slight Chance of Minor Geomagnetic Storms throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours, with peak activity recorded at GOES16 being an M1.0 flare seen at 17/1953UTC from AR3169 near the northeastern limb. There are currently eight numbered sunspot regions on the Earth-facing side, as although AR3165 is now no longer discernible in the southwest, this has been replaced in the southeast by newly-designated AR3170, which currently presents as an Hrx/Alpha, but is very likely hiding some complexity. The same is likely to be true of AR3169 in the northeast, with this group current analysed as a Cso/Beta.

Many of the remaining regions were unipolar and stable, however AR3167 saw some fading in its intermediate portion as a Dso/Beta; AR3166 saw penumbral growth in its intermediate spots at the expense of fading trailing spots to become a Dsi/Beta; while AR3163 saw areal growth in its leading spots to become an Eki/Beta.

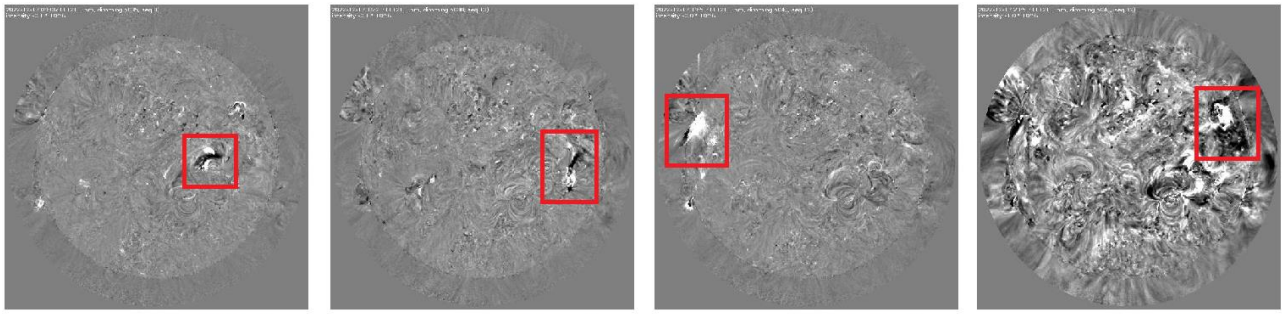


Figure 0: Roster of time-integrated AIA 211 dimmings (processing by SIDC ROB). None as yet has been confirmed as having generated any Earth-directed CMEs, with analysis ongoing.

A dimming and flare from near AR3166 around 17/0900UTC did not obviously result in any ejecta on coronagraphs in the period. There were three events otherwise noted: firstly a possible faint Coronal Mass Ejection (CME) seen heading largely westwards after a minor C-class flare and dimming in AIA211 seen around 17/1545UTC. This event has been analysed but results are not available at the time of writing. Initial thoughts are that any influence would be minor - if present at all. A second more impulsive event was tied to the M-class flare from AR3169. Corroborating imagery is only just becoming available and analysis will be conducted shortly. Again, this is considered relatively limb-ward and any Earth-based trajectory is thought marginal at worst. Thirdly and finally, a dimming from a C-class flare from near AR3167 around 17/2200UTC has yet to appear on imagery but is being watched for. No new Earth-directed CMEs are therefore

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

confirmed at the time of writing.

Solar Wind / Geomagnetic Activity: Solar winds, as observed at L1 by DSCOVR and ACE suffered an outage for the first six hours of the 24-hour reporting window, but on the evidence available have followed a slow regime. The solar wind speed was erratic but showed a downward trend from around 325 to 300km/s. The solar wind density was near the long-term average of single figures ppcc throughout, while the IMF was stable at or below 6nT, with a north-south component varying between +6 and -2nT. The phi angle was negative (towards the Sun).

The net result of the above solar wind measures was for provisionally Quiet geomagnetic activity throughout.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at Background levels.

High energy electron flux (greater than 2 MeV), as observed by GOES16, was at Background to Moderate levels. The associated 24-hour fluence was roughly level and well below Active (1e8 integrated pfu). Observed fluence at 18/0001UTC was 2.06e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is Likely to be Moderate, particularly for the remainder of the UTC weekend and perhaps the very start of the UTC working week, with AR3165 then due to rotate off the disc. Arriving AR3169 appears to be capable of similar levels of activity, and far side soundings as well as recent far-sided CMEs suggest that there may be a large region nearing the northeastern limb into the UTC week, perhaps preserving the risk of further M-class flares.

Solar Wind / Geomagnetic Activity: Two CMEs may give slight glancing impacts on Sunday 18 and Monday 19 December, although confidence in this aspect of the forecast is notably low.
Otherwise, solar winds are expected to follow a slow regime initially, perhaps becoming slightly elevated as CH54/- potentially affects Earth on day one, Sunday 18 December. A second fast wind from CH55/+ may then feature from midweek UTC.

The above combination of low confidence CME activity and two successive fast wind streams should combine to give a daily Slight Chance of G1, with Tuesday 20 December perhaps offering the best chance of favourable conditions.

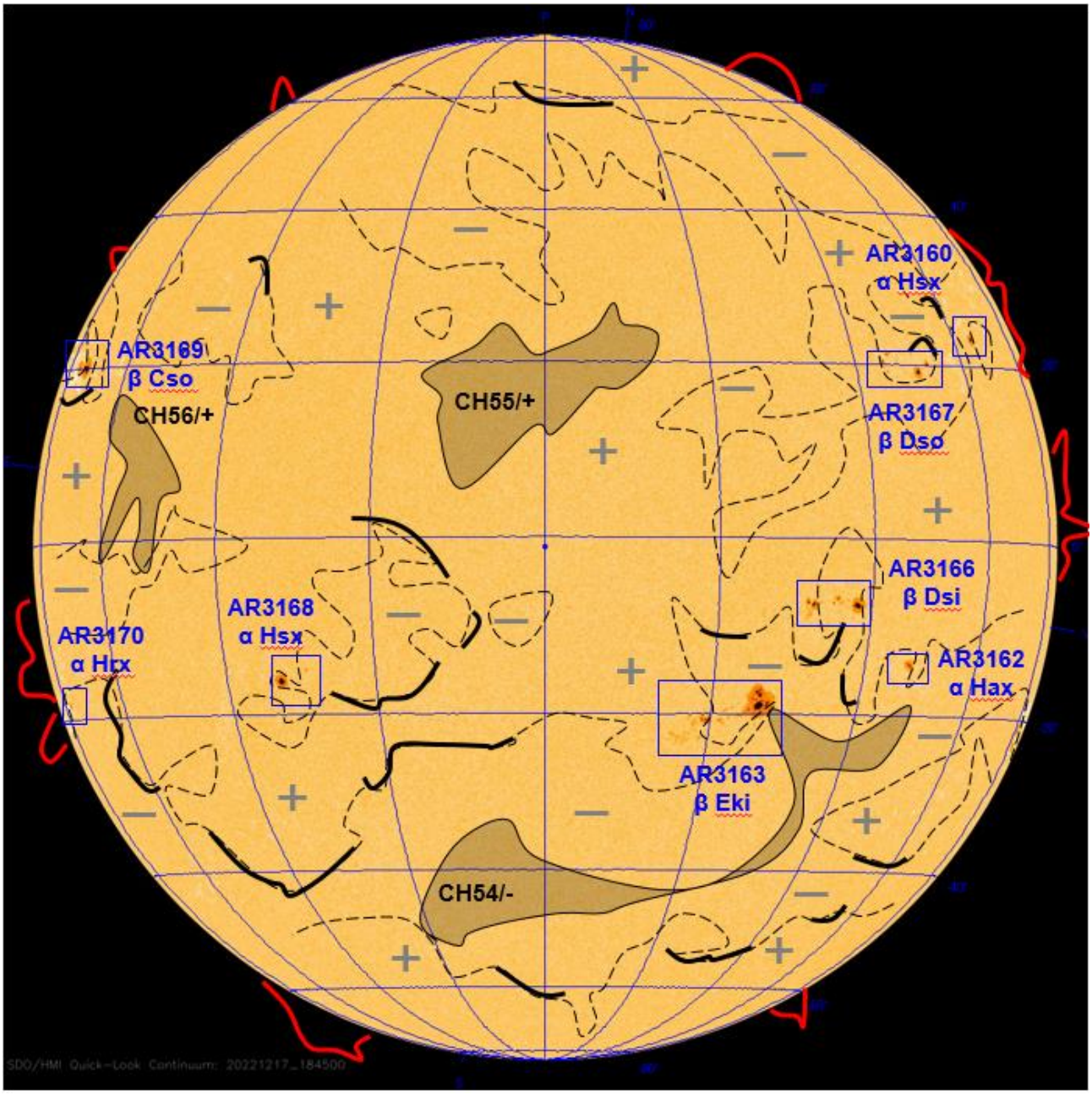
Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels throughout, although there is slight chance of S1 level storms with the occurrence of any notable flares.

High energy (greater than 2 MeV) electron flux is currently at Background to Moderate flux levels and expected to persist at these levels. The associated 24-hour fluence is expected to continue well below the Active (1e8 integrated pfu) threshold with a mostly flat trend anticipated.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Figure 1. Solar Analysis Valid 17/1845UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Geomagnetic Storms:

Two minor Coronal Mass Ejections (CMEs) may feature in this four-day forecast period. The filament lift off from the southwest around 14/0300UTC has been assessed as missing Earth, but brings a slight chance of glancing impacts during Sunday 18 December. Similarly, a CME which left the Sun on 15 December is also assessed as missing Earth, though it may have minor glancing impacts later on Sunday or perhaps into Monday 19 December.

Up to two fast wind streams may also feature in the coming four days. While Earth is currently transiting a sector of space characterised by a slow solar wind, CH54/- may feature from later on Sunday 18 December. This is a persistent feature, but reduced in size and northward extent compared to the previous rotation. However, its leading (western) edge is in a similar location, suggesting the timing of any enhancement that occurs is likely to follow the 27-day persistence, with solar wind speeds probably reaching Slightly Elevated levels of near 450km/s. This arrival is not obvious in current MOSWOC Enlil output, and confidence in this assertion is therefore lowered.

A lull in solar wind speed will perhaps most likely arrive on Tuesday 20 December, ahead of a possible entry into coronal hole 55's fast wind around midweek UTC, bringing Elevated wind speeds for a time.

All considered, there is a residual Slight Chance of G1 throughout given the multitude of low confidence events: starting with CH54's fast wind and up to two CMEs, probably giving way to a brief lull most likely on Tuesday 20 December, before a second fast wind arrives midweek.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	10	5	20
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

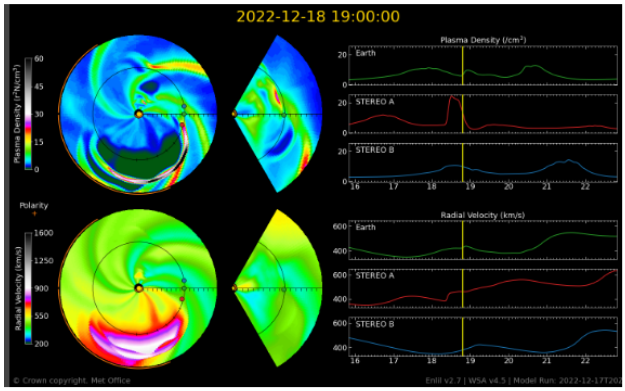
Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
14/1530	Partial	Filament	SW	400	Early 18 December	Low confidence
15/1743	Partial	Unknown	NE	790	18 into 19 December	Low confidence

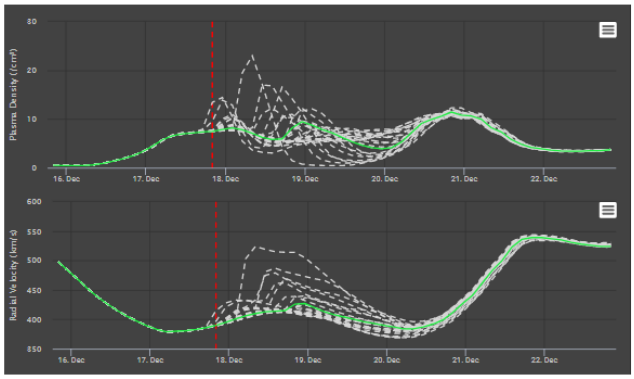
Figure 2: Latest MOSWOC Enlil and ensemble. Note the wide spread in solutions spread across multiple days to midweek UTC, the result of glancing incidence of up to two CMEs, although neither

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

is favoured for significant geomagnetic effects. Note also that a possible weak fast wind may arrive in the current UTC weekend (perhaps CH54/-). More assured is a second fast wind, with a most likely onset on Wednesday 21 December.





Radio Blackouts - X-Ray Flares:

There are now eight numbered sunspot regions on the visible disc, with AR3165 fading from view in the southwest, only to be replaced by AR3170 in the southeast. The Earth-facing side is largely the preserve of numerous unipolar sunspot groups, with changes in the larger bipolar groups of AR3166; AR3167 and AR3163 generally slow and not productive in terms of larger flares.

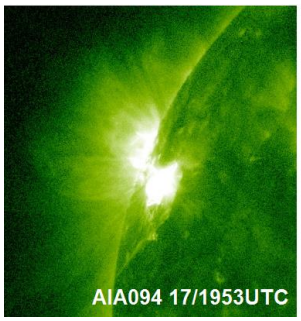
The front-side population of sunspot groups is likely to be in a state of flux through the forecast period. In the immediate term, the daily risk of flares should decrease as AR3165 departs, followed towards midweek by AR3160 and AR3167. In terms of sustaining risk, the arriving eastern limb groups of AR3169 and AR3170 may well be hiding detail, and it is very possible that a large region suggested by far-side soundings and some halo CMEs of the past week may arrive into the UTC working week to bolster the otherwise falling risk of significant flares, with this contribution yet to be determined.

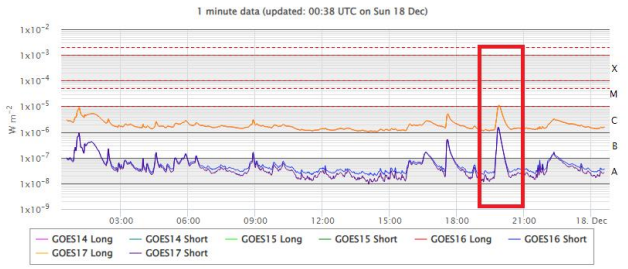
X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	60	60
Very Active	R3 to R5 X Class	No	15	15	5	5

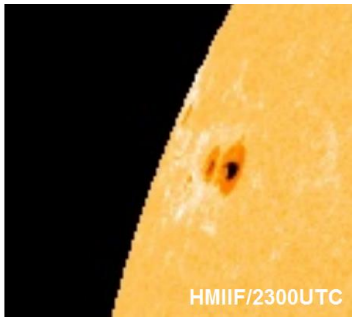
Figure 3: X-ray flare from AR3169. Trailing spots are now beginning to become visible in HMIIF.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.







Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) will most likely continue at Background levels, however the presence of large AR3165 near the potentially best-connecting western limb in the period will mean that a Slight Chance is maintained at first - above that suggested by the raw probabilities for the remainder of the (visible) disc sunspots. None of the present cohort has suggested that they are capable of S1+ level enhancements thus far, however some of the more recent far-side CME and flare activity as well as the M1.0 from AR3169 may have their contributions damp for being so far east, and time will tell if this will increase with westward progress.

For now, a daily Slight Chance of S1+ is largely tied to AR3165, reducing as this moves from the western limb onto the far side over the four days.

Radiation Storms Probability (Exceedance)	**Level (cm^{-2} sr^{-1} s^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC) (%)**	**Day 2 (00-24 UTC) (%)**	**Day 3 (00-24 UTC) (%)**	**Day 4 (00-24 UTC) (%)**
Active	**≥ S1**	No	15	15	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2 MeV) electron flux is following a stable low magnitude diurnal oscillation at present. Whilst CH54 and CH55 may become geoeffective in turn in the period, neither is currently envisaged as being capable of giving Active 24-hour integrated fluence, as per previous rotations. Confidence in this is perhaps lower than average, with both of these coronal holes' geometries changed since last pass, as well as the possible complicating presence of up to two CMEs. For its part, MOSWOC REFM suggests current modest electron fluence levels should persist throughout, although this does not allow for any transient activity.

GEO Electron Environment	**Level (cm^{-2} sr^{-1} day^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ 2 MeV ≥ $1x10^{8}$**	No	1	1	10	10
Very Active	**≥ 2 MeV ≥ $1x10^{9}$**	No	1	1	1	1

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.